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THE EFFECTS OF HIGH RELATIVE HUMIDITY ON PLANTS

By W. A. Cannon

The water relations of the desert plants are so delicately adjusted that an apparently slight variation in the available supply, either an increase or a decrease, or, what is directly associated with the water relations, in the humidity of the air, produces an instant and notable effect. This is not new, as a matter of fact, but new instances of it may be worth recording. I have already shown* how readily the ocotillo (*Fouquieria splendens*) responds to an increase in the water supply. Up to June 29, 1904, for several weeks the particular ocotillo referred to above was without leaves. This condition was directly connected with a long period of drought. On June 29, three gallons of water were poured slowly on the ground at the base of the plant; on July 1, leaf-buds were seen, which at 2 P. M. on the following day had become 1 cm. long, and four days afterwards the leaves were fully grown. But owing to the continuation of the drought, and the small amount of moisture in the air the leaves thus artificially produced very early withered and fell away and after about a fortnight the shrub was again denuded. The response of ocotillo to an increase in the water supply was observed on other occasions which are narrated in the paper above cited. Similar reactions have been seen in *Encelia farinosa*, *Cereus giganteus*, *Parkinsonia microphylla* and in other plants.

From what has already been said, it is apparent that a want or a supply of sufficient rain must materially modify the activities of the desert plants. For example, in the summer of 1904 the rainfall was nearly normal and the desert abounded in a pro-

* Transpiration of *Fouquieria splendens*. Bull. Torrey Club 32: 411. 1905.

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fusion of annuals, and the shrubs and trees, also, were covered with foliage and renewed their growth with great vigor. But in the present year (1905), the rainfall of summer was scant and the desert has quite another appearance. The annuals are wholly wanting and the manifestations of vegetative activity on the part of the longer-lived plants are very meager. Certain of the shrubs and the trees, however, show that the conditions obtaining this year are far removed from those of a drought. It is in fact to these conditions and to their apparent influence on the plants that I wish by this note to direct attention.

The rainfall and the relative humidity data for the summers of 1904 and 1905 show that the relative humidity for the two seasons was approximately the same but that the rainfall was very unlike. In fine, not one half the normal rainfall was recorded during the summer of 1905. The peculiar condition of a small rainfall accompanied by high relative humidity is accounted for by the occurrence of rains in plenty in all of the country adjacent to Tucson. The climate of the summer of 1905 was therefore not only different from that of the preceding summer but was so striking as to merit attention.

So long as the annuals failed to appear, as has been mentioned in an earlier paragraph, it naturally happened that the only plants which exhibited the effects of the summer's climate were those with a variable transpiring surface, that is, plants which increase their transpiring surface and decrease it in accordance with the fluctuation of the available water. Under the usual atmospheric conditions obtaining during a rainless period such plants would be leafless, or at least nearly so. As an example of these, *Parkinsonia microphylla*, the "palo verde" of the Mexicans, and *Fouquieria splendens*, the "ocotillo," may be selected. How did these forms respond to the anomalous climate of summer?

Palo verde is so called not only because it is a green tree from its foliage like other trees but chiefly because it is green even when the leaves have fallen. The twigs, branches and stem are green and all perhaps capable of emitting watery vapor from their surface and capable of carbon assimilation. Besides this, the leaves are so small (they average about 14.3 leaflets per

square centimeter) that their absence does not materially alter the usual appearance of the tree. Experiments on the transpiration of palo verde, not yet published, have shown that as compared with other desert forms, notably ocotillo, it has a low rate of transpiration, and that the possible range of transpiration is likewise small. That is, the "maximum" rate in summer when the leaves are on is not so much greater than the "minimum" when the leaves have fallen, as is the case with such other desert plants as have been studied. The foliar history of the palo verde is in complete accord with this observation. The tree forms leaves slowly and retains them a relatively long time. However, in cases of severe drought the leaves are shed and the necessary adjustment of the rate of transpiration is accomplished.

By the time of the summer rains in 1904 the leaves had fallen from the palo verdes near the Laboratory; after the rains had come leaves were again organized. This course of events, which may perhaps be the usual one, was not followed this season. Possibly owing to the extraordinarily heavy spring rains, and in part to small rains in June, the leaves were carried through the dry portion of the earlier part of July until the time for the summer rains had come, and then, despite the fact that the rainfall of summer was a meager one, they still persisted. With little doubt the reduced amount of rain of the summer would not under ordinary conditions of the atmospheric moisture be sufficient to permit the retention of the leaves. That they were retained is in the main due, I believe, to the high humidity which prevailed at the time.

A more striking example of the influence of high relative humidity in extending the life of leaves is found in the ocotillo. As was stated in an earlier paragraph the ocotillo when leafless responds to an improvement in its water conditions by quickly putting on a leaf-covering, and when dry weather returns this is nearly as quickly exfoliated. It is of interest to note also that this plant has a very high "maximum" rate and a very low "minimum" rate, and, therefore, that the possible seasonal variation is considerably greater than that of palo verde, for instance. The ocotillo then usually drops its leaves during a moderately

severe drought and reforms them promptly when even a slight rain falls. During the present season the history of the leaf-covering was quite different. In the earlier portion of June these plants were leafless, but owing to the occurrence of a small rain about the middle of the month, they came into leaf and were able to retain their leaves until the beginning of the summer rains. The leaves which were formed in June, as well as those formed later in the summer, remained on the shrubs during July, August, and are still (September 22) to be seen although now they are yellowing and preparing to fall.

The rainfall of the summer was not sufficient, I believe, to account for this behavior of the leaves of ocotillo since the ground was very dry, as indicated among other things by the failure of many seeds which were planted August 4 to germinate, and had the humidity been low in correspondence with the rainfall the leaves with little doubt would long ago have fallen. In whatever manner accomplished, it appears to have been mainly, or wholly, the high relative humidity which so changed the life conditions that the ocotillo, like palo verde, was able to retain its leaves during three months of the hot summer weather.

It is beyond the purpose of this note to discuss the means by which these desert plants were able to keep their leaves through so long a period of apparently unfavorable conditions. But it seems on the surface that aside from the fact that a large amount of moisture in the air would retard the rate of transpiration and thus assist the plant in better conserving the amount of water at its disposal, it is conceivable that the leaves of the plants really absorb atmospheric moisture in sufficient amounts to be of biological importance. This remains to be tested. I have shown, in the paper cited above, that stems of ocotillo absorb both water and atmospheric moisture, and Prof. F. E. Lloyd, who kindly permits me to make the announcement in advance of its publication,* has determined that a branch which is without leaves can absorb water in sufficient amount to induce leaf-formation. It will be of much interest, therefore, to learn whether the stems and the leaves of ocotillo especially can absorb moisture from

* See TORREYA 5 : 175.

the atmosphere in large enough quantity to enable it under such conditions as obtained the past summer to retain its leaves and thus to prolong the period of its vegetative activity.

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SYNCARPY IN MARTYNIA LUTEA

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The fruit of *Martynia* is a strongly curved, beaked, loculicidally two-valved capsule in which the somewhat fleshy exocarp falls away in two parts and exposes the variously armed fibrous woody endocarp, which dehisces from the tip of the strongly curved back towards the base. On the median line of the upper and lower carpels or only on that of the upper carpel is produced a prominent crest. In *M. lutea* only the upper carpel is crested.* Internally the capsule is five-celled through the expansion of each of the parietal placentae into two laminae which extend to the wall, thus forming four lateral cells and one large central cell into all of which the seeds extend from the margins of the laminar placentae.

In *M. lutea* growing on the grounds of the Missouri Botanical Garden I found the two cases of syncarpy which are figured here. Externally, they are identical in form while the internal structure is clearly seen from the figure of the cross-section of one of the fruits. The two specimens were found late in the fall after the disappearance of the exocarp so that any evidence offered by that part of the fruit is not available.

The relatively greater size of the abnormal fruit is shown by the cross-sections given. The relation of the elements of the fruit to the peduncle is worthy of notice. In the normal fruit the

* Here I use upper and lower in the popular instead of in the strict morphological sense of dorsal and ventral. Britton and Brown in their Illustrated Flora evidently do the same. They say of *Martynia*: "the endocarp * * * crested below or also above," and of *M. Louisiana* Mill. (= *M. proboscidea* Glox.): "the endocarp crested on the under side only." The figure given represents the fruit in an inverted position, the horns turning downward instead of upward, so that the statement appears to be an oversight due to lack of familiarity with the habit of the plant.